TT 14: Many-Body Quantum Dynamics I (joint session DY/TT)

Time: Wednesday 13:30–14:45 Location: H6

Invited Talk TT 14.1 Wed 13:30 H6

Nanofriction in Ion Coulomb Systems — •Tanja Mehlstäubler — PTB, Bundesallee 100, 38116 Braunschweig

Single trapped and laser-cooled ions in Paul traps allow for a high degree of control of atomic quantum systems. They are the basis for modern atomic clocks, quantum computers and quantum simulators. Our research aims to use ion Coulomb crystals, i.e. many-body systems with complex dynamics, for precision spectroscopy. This paves the way to novel optical frequency standards for applications such as relativistic geodesy and quantum simulators in which complex dynamics becomes accessible with atomic resolution. The high-level of control of self-organized Coulomb crystals opens up a fascinating insight into the non-equilibrium dynamics of coupled many-body systems, displaying atomic friction and symmetry-breaking phase transitions. We discuss the creation of topological defects and Kibble-Zurek tests in 2D crystals and present recent results on the study of tribology and transport mediated by the topological defect.

TT 14.2 Wed 14:00 H6

Quantum many-body scars in tilted Fermi-Hubbard chains — •Jean-Yves Desaules[1], Ana Hudomal[1,2], Christopher Turner[1], and Zlatko Papić[1] — [1]School of Physics and Astronomy, University of Leeds, Leeds, United Kingdom — [2]Institute of Physics Belgrade, University of Belgrade, Belgrade, Serbia

Motivated by recent observations of ergodicity breaking due to Hilbert space fragmentation in 1D Fermi-Hubbard chains with a tilted potential [Scherg et al., arXiv:2010.12965], we show that the same system also hosts quantum many-body scars in a regime $U=\Delta>J$ at electronic filling factor $\nu=1$. We numerically demonstrate that the scarring phenomenology in this model is similar to other known realisations such as Rydberg atom chains, including persistent dynamical revivals and ergodicity-breaking many-body eigenstates. At the same time, we show that the mechanism of scarring in the Fermi-Hubbard model is different from other examples in the literature: the scars originate from a subgraph, representing a free spin-1 paramagnet, which is weakly connected to the rest of the Hamiltonian's adjacency graph. Our work demonstrates that correlated fermions in tilted optical lattices provide a platform for understanding the interplay of many-body scarring and other forms of ergodicity breaking, such as localisation and Hilbert space fragmentation.

TT 14.3 Wed 14:15 H6

(Classical) Prethermal phases of matter — •Andrea Pizzi[1], Andreas Nunnenkamp[2], and Johannes Knolle[3] — [1]Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, United Kingdom — [2]School of Physics and Astronomy and Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, University of Nottingham, Nottingham, NG7 2RD, United Kingdom — [3]Department of Physics, Technische Universität München, James-Franck-Straße 1, D-85748 Garching, Germany

Systems subject to a high-frequency drive can spend an exponentially long time in a prethermal regime, in which novel phases of matter with no equilibrium counterpart can be realized. Due to the notorious computational challenges of quantum many-body systems, numerical investigations in this direction have remained limited to one spatial dimension, in which long-range interactions have been proven a necessity. Here, we show that prethermal non-equilibrium phases of matter are not restricted to the quantum domain. Studying the Hamiltonian dynamics of a large three-dimensional lattice of classical spins, we provide the first numerical proof of prethermal phases of matter in a system with short-range interactions. Concretely, we find higher-order as well as fractional discrete time crystals breaking the time-translational symmetry of the drive with unexpectedly large integer as well as fractional periods. Our work paves the way towards the exploration of novel prethermal phenomena by means of classical Hamiltonian dynamics with virtually no limitations on the system's geometry or size, and thus with direct implications for experiments.

TT 14.4 Wed 14:30 H6

Master equations for Wigner functions with spontaneous collapse and their relation to thermodynamic irreversibility* — •Michael te Vrugt[1,2], Gyula I. Tóth[3], and Raphael Wittkowski[1] — [1]Institut für Theoretische Physik, Center for Soft Nanoscience, Westfälische Wilhelms-Universität Münster, D-48149 Münster, Germany — [2]Philosophisches Seminar, Westfälische Wilhelms-Universität Münster, D-48143 Münster, Germany — [3]Interdisciplinary Centre for Mathematical Modelling and Department of Mathematical Sciences, Loughborough University, Loughborough, LE11 3TU, United Kingdom

Wigner functions allow for a reformulation of quantum mechanics in phase space. They are, as shown in our recent work [1], very useful for understanding effects of spontaneous collapses of the wavefunction as predicted by the Ghirardi-Rimini-Weber (GRW) theory. We derive the dynamic equations for the Wigner function in the GRW theory and its most important variants. The results are used to test, via computer simulations, David Albert's suggestion that the stochasticity induced by spontaneous collapses is responsible for the emergence of thermodynamic irreversibility. We do not observe the equilibration mechanism proposed by Albert, suggesting that GRW theory cannot explain the approach to thermal equilibrium.

[1] M. te Vrugt, G. I. Tóth, R. Wittkowski, arXiv:2106.00137 (2021)

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